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**METHOD FOR ADJUSTING THE DEFORMATION GEOMETRY OF A DEFORMATION
TOOL IN AN OPTIMIZING MANNER, CORRESPONDING DEFORMATION TOOL AND
APPROPRIATE TEST TOOL**

Field of the invention

[0002] The invention concerns a process for the optimal adjustment of the deformation geometry of a deformation tool provided for deforming a sheet (preferably sheet metal) according to the precharacterizing portion of claim 1. Further, the invention concerns a test tool (experimentation tool, trial-and-error tool) for carrying out the process according to the precharacterizing portion of claim 12, and a commensurate deformation tool according to the precharacterizing portion of claim 15.

Background of the invention

[0003] A process, an experimentation tool and a deformation tool of this type are already well known. In DE 41 32 607 A1 a process and a device are disclosed for adjusting a specific position of each tool set of a multistage process. For this, first tool sets for multistage sheet metal deformation are mounted on a base plate and the position of the base plate is adjusted in a separate initial adjustment press under simulation conditions, the precise position of the tool is noted, and the information is used to position the tool subsequently in the multistage process. An adjustment of this type of a deformation tool is comparatively time consuming and complex.

Summary of the invention

[0004] It is the task of the invention to provide a process of the above described type which makes possible a relatively

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simple and reliable adjustment of the deformation geometry of a deformation tool.

[0005] It is further the task of the invention to provide a suitable test tool for carrying out the process and a suitable deformation tool.

[0006] For the solution of the task a process having the characteristics of claim 1 is proposed. The process is characterized in that the sheet metal is preformed by means of the deformation tool to be adjusted; subsequently, for the correction of the sheet metal geometry at least one partial area deformation is introduced into the sheet metal by means of a test tool, and after obtaining the reliable sheet metal geometry the geometry of the partial area deformation is consulted or relied on for adjusting the deformation geometry of the deformation tool.

[0007] Herein "preforming" of the sheet metal is understood to mean a deformation thereof with the deformation tool to produce a sheet metal geometry which does not sufficiently precisely correspond to the predetermined intended deformation geometry. For example, a shape deviation in a preformed sheet metal can occur as a consequence of a not avoidable elastic sheet metal return deformation (spring-back), of which the dimensions depend in particular upon the respective sheet metal material characteristics. By means of the inventive process it is now possible to eliminate, from an already preformed sheet metal, the present geometric and/or shape deviations from the intended permissible deformation geometry, in relatively simple and reliable manner, on the same sheet metal, and therewith to utilize the obtained correction data to adjust the therewith to

be adapted deformation tool, which is in particular to be employed as a series tool. For this, first at least one suitable partial area deformation is introduced by means of the test tool for achieving a necessary geometric or, as the case may be, shape adjustment on the preformed sheet metal, which is a test sheet metal. After calibrating an acceptable sheet metal geometry there occurs a corresponding calibration or, as the case may be, conformance of the deformation geometry of the deformation tool, so that this can, in particular as a series tool, introduce into the sheet metal to be deformed, thus obtaining a reliable partial area deformation of the sheet metal geometry as necessary in the respective sheet metal to be deformed. The test tool serves therewith as an auxiliary tool for introducing and determining at least one suitable partial area deformation on a test sheet metal which had been preformed by means of the deformation tool, while the deformation tool to be optimized with respect to its deformation geometry is not employed for a test deformation of this type on the preformed test sheet metal. The sheet metal could be, for example, sheet metal for a vehicle body.

[0008] The partial area deformation can advantageously be introduced into at least one edge area of the preformed sheet metal. This makes possible, for example, a main curvature adjustment or the conformance of a preformed sheet metal, for example, an engine hood which has been preformed by means of the deformation tool, which on the basis of its material-dependent spring-back behavior is not shaped with sufficient shape precision, so that by the follow up or subsequent introduction of a suitable partial area deformation using the test tool on the preformed sheet metal a necessary shape or, as the case may

be, curvature correction on the same sheet metal can be achieved.

[0009] A correction of this type is made possible relatively effectively by introduction of a suitable partial area deformation in an edge area of the sheet metal, which projects or extends substantially perpendicular to the main plane of orientation of the sheet metal. Thereby the associated edge area is appropriately shortened in its longitudinal extent, so that the preformed sheet metal - after completion of elastic spring-back deformation - along its edge is subject to a desired pulling force within the main plane of extension, such that an adjustable and sufficiently precise shape tolerance or precision of the sheet metal is achievable.

[00010] Preferably, the partial area deformation is introduced manually into the preformed sheet metal using an auxiliary deformation tool. This provides for introduction of a suitable partial area deformation into the preformed sheet metal in a way that is easily manipulated and flexibly adaptable to the respective deformation geometry.

[00011] According to a preferred embodiment of the invention, the deformation geometry of the auxiliary deformation tool is utilized or drawn upon for adjusting the deformation geometry of the deformation tool. The auxiliary deformation tool allows therewith a comparatively simple introduction of one or more partial area deformations in the preformed sheet metal and, at the same time, in the framework of one or more test deformations, a relatively rapid determination of a suitable deformation geometry on the preformed sheet metal, wherein based on the deformation geometry of the auxiliary deformation tool it

becomes possible to directly select or arrive at the deformation geometry to be used to optimize the deformation tool to be employed in particular in series production.

[00012] It is possible to simultaneously introduce into the preformed sheet metal at least two partial area deformations and/or to introduce at least two partial area deformations time-wise separated from each other. It is also possible to introduce a multiplicity of geometrically distinct shaped partial area deformations into the preformed sheet metal. This variability with respect to the geometric design, the positioning and/or the sequence of introduction of the partial area deformations on the preformed sheet metal enables a targeted and comparatively simple reproducible deformation geometry adjustment for obtaining a sufficient shape precision of the test sheet metal.

[00013] The partial area deformation can be in the form of at least one sheet edge-open recess. This type of recess is also known as a crimp or bead and can be impressed in relatively simple manner including manually using a suitable auxiliary deformation tool in the preformed sheet metal. Preferably, the change in the sheet metal geometry following the partial area deformation is checked on the basis of a sheet metal geometry acceptability test, in particular with employment of a checking device, which for example could be one or more, in certain cases differing, profile gauges or form gauges. This enables a precise and easy to manipulate geometric adaptation using the test tool on a preformed sheet metal.

[00014] The sheet is preferably sheet metal, in particular aluminum or aluminum alloy. In the case of aluminum alloy the

tendency toward elastic spring-back deformation due to materials is greater than in the case of corresponding steel sheet metal, so that the advantageous effect of the inventive process is particularly valid in the case of aluminum sheets to be deformed. Aluminum components in need of deformation are increasingly employed in vehicle bodies.

[00015] The task is further solved by a test tool having the characteristics of claim 12, which is characterized by a carrier body, to which an adjustment element is sideably guided for sheet metal deformation, and at least one deformation insert. Therein it is possible that one respective, in particular replaceable or exchangeable, deformation insert be comprised of at least two insert parts essentially complimentary in deformation geometry, wherein a first insert part is secured to the adjustment element and a second insert part is secured to the carrier body. A test tool of this type enables a targeted introduction of a variable partial area deformations adapted to the respective necessary geometric requirements in the preformed sheet metal. The test tool is used to cause a supplementary and localized deformation simulation on the preformed sheet metal. The test tool can therein advantageously exhibit a manually releasable insert part securing system. This makes possible an easy to manipulate equipping or outfitting of the test tool with respective associated insert parts, so that various partial area deformations can also be introduced comparatively rapidly on the preformed sheet metal. The securing system can be, for example, a clamp and/or a screw securing system.

[00016] For solving the task according to the invention there is further provided a deformation tool having the characteristics of claim 15, which is characterized thereby,

that it includes a stamp and a die plate, wherein at least the stamp includes at least one receptacle seat for the removable securing of an associated deformation tool insert part for bringing about a partial area deformation in the sheet metal. In certain cases a stamp insert part and/or a die plate insert part can be identical to the corresponding insert parts of the test tool. The test tool obtained geometric deformation results can therewith be utilized directly for the correcting or adaptation of the deformation geometry of the deformation tool. The deformation geometry of the deformation tool as a series tool can therein be adapted relatively rapidly in a predetermined partial deformation area and with flexibility to the respective deformation requirements to be satisfied.

[00017] According to a preferred embodiment a stamp insert part and, in certain cases, a die plate insert part, are securable in at least one edge area of the deformation tool. The deformation tool can therewith be in such a shape or form, that in the case of a total disregard of a fundamentally not avoidable elastic spring back deformation of the sheet metal a supplemental geometry-correcting edge area deformation occurs on one plane of the sheet metal. Therewith, following the occurrence of too strong of an elastic sheet spring-back deformation, it is possible by means of provision of the stamp insert part, and in certain cases the die plate insert part, in at least one edge area of the deformation tool, to supplementally produce a suitable partial area deformation in the sheet metal so that this is subjected to a drawing or tension force compensating at least partially the elastic spring back deformation.

[00018] According to a further alternative embodiment, the die plate exhibits at least one embedded deformation recess adapted or essentially complementary to the deformation geometry of at least one associated stamp insert part. The incorporation of a deformation recess into the deformation geometry for a partial area deformation in the die plate can be useful in particular in such partial area deformations, for which or wherein the associated stamp and die plate side deformation geometries need not be matched exactly complimentary to each other, so that also different stamp side deformation geometries can be combined with a non-changing deformation recess.

Brief description of the drawings

[00019] Further advantages of the invention can be seen from the following description.

[00020] The invention will now be described in greater detail on the basis of multiple preferred embodiments with reference to the schematic drawings.

[00021] There is shown in:

Fig. 1 a perspective view of a partially represented sheet metal which was preformed by means of a deformation tool and by means of a test tool with inventive partial area deformations;

Fig. 2 a front view of a partially shown preformed sheet metal with inventive partial area deformations in the edge area according to a further embodiment;

Fig. 3 a perspective view of a manually adjustable, inventive test tool with multiple exchangeable deformation inserts;

Fig. 4 a perspective view of a partially shown, inventive deformation tool with a stamp and a die plate;

Fig. 5 a perspective view of a detail of the stamp of an inventive deformation tool according to a further embodiment; and

Fig. 6 a perspective view of a detail of the matrix of the deformation tool of Fig. 4.

Detailed description of the drawings

[00022] Fig. 1 shows in schematic partial representation a sheet metal 10 deep drawn on the basis of a deformation tool 12 shown in greater detail on the basis of Fig. 4, having the shape of a motor hood of a motor vehicle. The sheet metal 10 exhibits a geometric shape preformed by means of the deformation tool 12, which corresponds essentially to the desired intended geometry of the vehicle body part to be produced. However if there occurs an elastic spring back deformation which is fundamentally not to be avoided in the case of deep drawn aluminum sheet metal, strong, on the basis of which it is often not directly possible to achieve due to, even in the case of a correctly shaped deformation tool with respect to the deformation geometry, a sufficient precision of the deformation exactness of the sheet metal 10, in particular in regard to a previously provided sheet curvature in the main extension plane 20.

[00023] For adjusting or conforming the curvature of the thus preformed sheet metal 10, a number of partial area deformations 14 are thus subsequently introduced in an edge area 18 manually by means of a test tool 16 described in greater detail below on the basis of Fig. 3. In the present embodiment the partial area

deformations 14 are sheet metal edge-open recesses 26 or, as the case may be, crimps or beads. By means of the partial area deformations 14 in the edge area 18, which is essentially a sheet metal edge 22 projecting perpendicular to the main orientation plane 20 of the sheet metal 10, there is produced in the sheet metal a tensile force acting in the direction of the arrows 11, which bring about a desired sheet metal curvature increase in the main orientation plane 20. Therein, the increase in the sheet metal curvature is variably adjustable by the orientation, number and/or geometric design of the partial area deformations 14. After achieving an acceptable sheet metal geometry the geometry of the partial area deformation 14 is utilized for optimizing the adjustment of the deformation geometry of the deformation tool 12.

[00024] Fig. 2 shows in schematic representation a further illustrative embodiment of a preformed sheet metal 10 form adapted appropriately according to the arrow 13, wherein the edge area 18 exhibits partial area deformations 14 or, as the case may be, recesses 26 of shapes differing geometrically from one another, introduced by the test tool 16. In this illustrative embodiment the recesses 26 are introduced in segments of the edge area 18 with different breadth, so that the recesses 26 differ with respect to their length, not however with respect to their cross-sectional contour. Thereby it is possible, using the same test tool 16, to introduce the recess 26 in the edge area 18 of the sheet metal 10. The illustrative embodiment of Fig. 2 corresponds otherwise essentially with that of Fig. 1.

[00025] Fig. 3 shows a test tool for sheet metal deformation indicated overall with reference number 16, which includes a

carrier body 28, to which an adjustment element 30 is mounted slideably guided according to the double arrow 58 and secured via an adjustment or set screw 56. The test tool 16 further includes at least one, in the illustrated embodiment three, manually exchangeable deformation inserts 32, which respectively are comprised of two deformation-geometric essentially complimentary insert parts 34. From the associated insert parts 34, one first insert part 36 can be secured manually to the adjustment element 30 and a second insert part 38 on the carrier body 28. For this, a releasable insert part securing system 40, for example, respective screw connections, is provided, wherein by the same means a suitable key 54 is releasably secured manually on the carrier body 28 or as the case may be on the adjustment element 30 and, as required, is again releasable.

[00026] For the easier manipulation of the test tool 16 this includes a grip or holder element 60, on which a service person can hold the test tool 16 in particular for positioning the same against sheet metal 10 (not shown in Fig. 3) to be form fitted. For this, the test tool 16 is positioned by hand in such a manner, that between the two insert parts 34 spaced apart from each other and mounted on the test tool 16, there is positioned there-between, for example, an edge area 18 of the preformed sheet metal 10 to be subsequently deformed. By suitable operation of the set screw 56 it is now possible to manually introduce into the preformed sheet metal 10, via the insert parts 34 with frontal areas approaching each other in the test tool 16, one or more definite partial area deformations 14. When using deformation inserts 32 of diverse deformation geometries it becomes possible to introduce into the preformed sheet metal 10, by means of the test tool 16, partial area deformations 14 differing geometrically from each other. The

test tool 16 is an auxiliary deformation tool 24. The sheet metal geometry changing by means of a respective partial area deformation 14 is checked on the basis of a sheet metal geometry acceptability test, for example, by means of a checking device (not shown in the figures) such as a shape gauge. After determining one or more partial area deformations 14 applicable for sheet metal geometry conformance, the geometric design thereof is utilized for appropriate optimizing adjustment of the deformation geometry of the deformation tool 12, which is a series tool. Various embodiments of partial area deformations (impressions) can be introduced in advance in the preformed sheet metal 10 (press part) by means of the test tool 16, wherein the sheet metal 10 could be a single or also a composite component or subassembly. The preformed sheet metal 10 is therewith a test part, into which suitable partial area deformations 14 can be introduced quickly, variably and economically by means of the test tool 16. Thereby it becomes possible to dispense with test changes which are time intensive and in certain cases require multiple changes on one deformation tool 12, possibly even multiple deformation tools 12, such as for example in the form of welding, milling, grinding and the like.

[00027] Figs. 4, 5 and 6 show in schematic representation various embodiments of a deformation tool 12 suitable for carrying out the above-described process. The deformation tool 12 is a deep draw tool for series production and includes a stamp 42 and a die plate 44. The stamp 42 exhibits in one edge area 52, according to Figs. 4 and 5, a plurality of receptacle seats 46 spaced apart from each other. The receptacle seats 46 are designed in such a manner that they allow a manual securing and removal of a respective associated deformation tool insert

48, in the present example a respective stamp insert part 48. Securing screws 62 are preferably employed as the securing system for the stamp insert part 48. According to Fig. 6 the die plate 44, in comparison, exhibits a plurality of recessed and respectively deformation stops 50 essentially complimentary to the deformation geometry of the associated stamp insert (part 48. These deformation stops 50 are incorporated in a corresponding edge area 52 of the die plate 44.

[00028] The stamp 42 can, in accordance with Fig. 4, also include free standing receptacle seats 46, which thus are not occupied with associated stamp insert parts 48, the receptacle seats 46 not having negative consequences on the sheet metal 10 during the actual deformation process. In these areas of missing deformation surfaces of the deformation tool 12, since there are deformation recesses 50 supplementally incorporated in the matrix 44, no supplemental partial area deformations 14 are introduced in the sheet metal 10, since the sheet metal 10 is not subject to any deformation tensions necessary therefore. The receptacle seat 46 of the deformation tool 12 need thus not be occupied over the entire deformation tool insert 48 for a sufficiency precise sheet metal deformation, but rather can in certain cases also remain "free".

[00029] The deformation tool 12 is thus suitable for bringing about, supplementally to the conventional sheet metal deformation, one or more variable partial area deformations 14 in the sheet metal 10, correcting with respect to the deformation geometry, and in particular by the changing out of the stamp insert parts 48. Therein the sheet metal 10 to be deformed can already have been subjected to a previous partial deformation or, in certain cases, could also be pre-deformation

by means of the deformation tool 12 and thus be undeformed, that is, can be planar. This means that at least one partial area deformation area 14 in the framework of a deep drawing process can be introduced in a first drawing or tensioning and/or in one or more subsequent drawings or tensionings of the sheet metal 10.

[00030] It is thus possible to undertake a sheet metal specific deformation geometry optimization using the deformation tool 12. The relatively time intensive and complex determination of an optimizing geometry can be carried out by means of the test tool 16 on a preformed sheet metal 10, without having to consult or refer back to the deformation tool 12. Only after determining an optimal deformation geometry using the test tool 16 on the preformed sheet metal 10 is the deformation tool 12 geometrically adapted or conformed in an easy to manipulate or execute manner appropriately for a serial tool. The actual deformation process for preforming or for series forming of the sheet metal 10 is per say known, so that a detailed description thereof can be dispenses with.

[00031] It is of course also possible that the process described above in particular with respect to automobile body parts can also be applied advantageously to other diverse sheet metal parts, such as a motor hood, a trunk lid, a fender, sheet metal lagging, and the like. Therein the partial area deformations, for example in the form of energy absorbing crimps or beads, can be applied to comparatively long flanges or bevels and/or injection flanges of a vehicle chassis sheet metal for bringing about a desired shape stability of the deformed sheet metal. The above mentioned advantages exhibit themselves particularly effectively in the deformation tools which are

provided as series tools for deep drawing of aluminum sheet metal.